THERMAL RUNAWAY IN HIGH PURITY ALUMINA

H. W. Jackson, M. Barmatz and P. Wagner, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California 91109

Thermal runaway is a phenomenon in which the temperature in a sample climbs steadily and reaches the melting point at some location in a sample when it is heated in a microwave cavity that is excited at a constant input power above some threshold. For any constant input power level to the cavity below that threshold, the sample eventually attains a steady state. temperature profile that is everywhere a finite amount below the melting temperature.

Reports of experimental observations and theoretical studies of thermal runaway have been published by a number of investigators. Understanding, controlling, and avoiding thermal runaway are important issues in microwave processing of materials. A steep increase in the loss factor ε_r'' as a function of temperature is usually assumed to be the. dominant cause of thermal runaway. In earlier work we investigated this assumption with the aid of a theoretical model that included accurate solutions of coupled electromagnetic and thermal equations. Parametric studies indicated that the assumed "dominant came" by itself was not sufficient to produce thermal runaway in a cylindrical sample located on the axis of a resonant cylindrical cavity that is excited in a TM010 mode. For this mode there is no angular dependence or axial dependence in the electromagnetic fields or in the microwave power absorption density. The parametric studies covered materials having thermophysical properties similar to alumina and having 10ss factors as great as or greater than that for 97.5% alumina at each temperature.

The present study is concerned with higher purity alumina, 99.5%, for which the loss factor ε_r'' is much lower at each temperature than the cases we studied earlier but where ε_r'' still rises steeply with temperature. Results calculated with the same accurate model used earlier are presented here. They indicate that a phenomenon rather similar to thermal runaway can occur in this high purity alumina for some sample sires. However, instead of discontinuous behavior in the beating response behavior at a threshold power level, the steady state temperature climbs steeply but continuously to the melting point over a narrow range of constant input power levels. Other abrupt features in the beating curves are revealed by the calculation for some sample sizes. Only when power absorbed by the cavity walls is taken into account does any of this unusual behavior occur. Additional parametric studies that utilize our transient beating theory indicate that there is no sigmoid ("S" shaped) behavior of the steady state heating curves for the cases wc have examined. [Work supported by NASA].